APPARATUS FOR FILTERING AND SEPARATING FLUIDS

BACKGROUND OF THE INVENTION

The invention relates to an apparatus for filtering and separating fluids, preferably of salt-containing liquids, particularly on the basis of the principle of ultrafiltration. The apparatus comprises a pressure housing with an inlet for the fluid and outlets for the retentate and the permeate. The housing includes a plurality of spaced filter elements in the form of membrane pillows, around which the fluid is conducted. The filter elements are arranged in the housing in separate stacks of membrane pillows, which are arranged in series in the fluid flow path.

Such an apparatus is known for example from EP-A-0 707 884. In the apparatus described in this publication, the stacks of spaced membrane pillows define together an unrestricted flow path for the fluid through the apparatus, whereby the fluid can pass through the apparatus from the inlet for the fluid to the outlet for the retentate at a relatively high speed. With this apparatus, [illegible] are achieved. For the operation of this apparatus therefore, however, [illegible] pumps are required, that is, one pump for generating a high operating pressure at which the apparatus needs to be operated and a second pump for pumping the fluid at high flow speeds through the apparatus. The operation of the [illegible]

[illegible] for generating the high operating pressure in cooperation with the pump employed for pumping the fluid at high flow speed through the apparatus are problematic.

It is the object of the present invention to provide an apparatus for filtering and separating fluids wherein for generating the operating pressure in the pressure housing and for pumping the fluid to be filtered or separated through the housing only one pump is needed. The apparatus should also be easy to clean and service when this should become necessary. Also, the apparatus should be relatively simple and inexpensive to manufacture while presently known design principles are maintained. Furthermore, it should be possible to adapt the apparatus to the individual load factors of the fluid to be separated.

SUMMARY OF THE INVENTION

In an apparatus for filtering and separating fluids, including a pressure-tight housing having a fluid inlet, a retentate outlet and a permeate outlet, a plurality of stacks of membrane filter elements are arranged in the housing adjacent one another and joined such that the fluid is conducted through the stacks of membrane filter element in a series flow pattern and each stack includes a plurality of spaced membrane pillows arranged in spaced [illegible] such that the fluid is conducted [illegible].

[illegible] pump [illegible] the apparatus since, be- [illegible]

separated as it is possible with the prior art apparatus which however requires a relatively high energy input. The fluids may be solutions from waste water treatment processes, which are rich in salts as they are present for example in animal husbandry, that is, for example, pig and cattle urine but the fluid may also be sea water. For the adaptation to a particular fluid, the number of stacks and the number of membrane pillows in a stack can be selected as necessary.

Since the apparatus can be operated at a very high operating pressure of up to 120 bar or, under certain conditions, above this value, a certain pressure drop between the inlet and the outlet of the apparatus as a result of the meander-like flow path of the fluid through the stack can be accommodated.

In order to ensure that, with the present design, the fluid flows through subsequent stacks in a meander-like fashion, the stacks form each a volume which is in communication with an inlet and an outlet for the fluid but which is otherwise closed. In this way, it is also ensured that the same volume flow passes through all the stacks of an apparatus.

In order to establish such a closed stack volume with a simple design the space is delimited preferably by a separating element which may be square or oblong and the separating element includes an inlet and an outlet preferably in the form of [illegible] between two membrane pillows [illegible].

The membrane pillows may have a shape as desired; they are however, preferably of a form corresponding to the shape of the [illegible] apparatus [illegible] the shape of an [illegible] element [illegible]

outer membrane elements, which form the membrane pillow, is discharged.

It is very advantageous to arrange the membrane pillows in the stack in a displaced fashion such that the end of each alternate membrane pillow is disposed adjacent the separating element. In this way, no particular means are needed for redirecting the fluid, after passing over one side of a membrane pillow, to flow over the opposite side in the opposite direction. With such a staggered arrangement of the membrane pillows, the membrane pillows themselves form the redirecting means for the fluid.

Although, it is possible to make the membrane pillows, which basically have a relatively unstable shape, stable by suitable support structures, such stabilizing means are relatively expensive and they are also annoying during disassembly in case of damage to the membrane pillows or during servicing. Also, the provision of spacer elements as they are known from the state of the art and on which the membrane elements can be held in a stable state, has the disadvantage that the pressure drop of the fluid from the inlet of the apparatus to the outlet thereof is increased. There is also the likelihood that deposits are formed at the support points of the membrane pillows on the spacer elements, which must be avoided under any circumstances. [illegible] [illegible] [illegible] membrane pillows. The stabilizing element is so designed that the membrane element is held in a firmly stretched manner also at [illegible]

The stabilizing element consists preferably of plastic, but other suitable materials may be used such as compound materials or even metal. The selection of the material for the stabilizing element depends essentially on the type of fluid, and the fluid pressure, which is maintained in the apparatus.

It is also advantageous if annular spacer elements are used for the outer spacing of the membrane pillows. The annular spacer elements may include elastomer sealing elements. But also strip-like spacer elements could be provided for the outer membrane elements. This would facilitate the mounting of the stack of membrane pillows. The sealing elements can be formed by a separate [illegible] ring. But, with the use of a suitable material, an annular spacer of an elastic material may provide a seal without the need for a sealing element, in addition to maintaining a certain space between the membrane pillows.

As indicated already, the membrane pillow includes at least one permeate discharge opening, but it may be advantageous to provide a plurality of permeate discharge openings in the membrane pillow. Preferably, two discharge openings are arranged on an imaginary longitudinal axis of the oblong membrane pillow at different distances from the adjacent ends of the membrane pillows. In this way the membrane pillows arranged in a stack can be displaced with respect to one another, such [illegible] [illegible] [illegible], respectively, the ends of the membrane pillow, a meander-like flow channel is formed for the fluid by the stack [illegible].

Such an arrangement of the stacks has the advantage that they can be easily accommodated in the apparatus. This is particularly true if the stacks are received in two semi-circular shell elements, which each hold two stacks of membrane pillows. The inner cross-section of the two interconnected shell elements is preferably round when the two shell elements are assembled. The dimensions are preferably so selected that the stack of membrane elements is tightly engaged between the two semi-circular shell elements. The membrane pillow can then, in cooperation with the spacer elements disposed therebetween, ensure that no additional mounting bolts or similar elements are necessary to keep the permeate discharge openings of the membrane pillow sealing while maintaining a predetermined distance between the membrane pillows for the flow of fluid therebetween.

Finally, the shell elements includes a permeate discharge channel, which extends longitudinally through the shell element and which is in communication with permeate discharge openings leading to the inner bottom area of the shell elements. With this arrangement, the permeate discharge channel is formed integrally with the shell elements which has the additional advantage that the need for separate discharge structures is eliminated, which reduces overall expenses for the apparatus.

An embodiment of the invention will now be described on the basis of the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a longitudinal cross-sectional view of a fluid filtering and separating apparatus with two stack shells, each [illegible]

Fig. 3a and Fig. 3b show the flow scheme through two adjacent stacks of membrane pillows,

Fig. 4a is a plane view of a separating element for disposition between two stacks of membrane pillows,

Fig. 4b is a side view of the separating element shown in Fig. 4a,

Fig. 5 shows schematically a membrane pillow as used in the apparatus according to the invention with two permeate discharge openings arranged at the narrow side of the membrane pillow,

Fig. 6a is a side view of a disc-shaped spacer element, and

Fig. 6b is a front view of the disc-shaped spacer element shown in Fig. 6a.

DESCRIPTION OF A PREFERRED EMBODIMENT

As shown in Fig. 1, the apparatus 10 for filtering and separating fluids consists essentially of a housing 11 which is closed and sealed at opposite ends by closure elements 110, 111 in a pressure tight manner. As circumferential sealing means 112, 113, for example O-rings may be used. The closure element 110 includes an inlet 12 for the fluid 15 to be supplied to the apparatus 10. The opposite closure element 111 includes an outlet [illegible] for the enriched fluid [illegible], which is called the retentate, [illegible] [illegible] lar in cross-section. However, another cross-sectional shape may be provided for the housing 11.

[illegible]

are contained in the [illegible] and are to be separated therefrom. Apparatus with [illegible] stack shells [illegible] one after the other have already been realized.

The stack shells [illegible] are all identical so that only one stack shell will be described below. As shown in Fig. 2, the stack shell [illegible] consists of two shell elements 19, 20. The shell elements 19, 20 have a semi-circular circumference. In the interior, they are essentially rectangular such that two elements which are joined form an inner space of essentially square cross-section. The shell elements 19, 20 may be interconnected by fastening means which are not shown in the drawing. It may be for example a removable bolt and nut joint. Two shell elements engage between them, in a tight manner, a stack 18, which is formed by a plurality of spacer element 16 and by membrane pillows 17 - see Figs. 2, 6a, and 6b. The membrane pillows 17 are arranged between the spacer elements 16. Such membrane pillows as they are used in the apparatus 10 for forming the stacks 18 together with the spacer elements 16 are disclosed for example in EP-[illegible].

Since the membrane pillows 17 used in the apparatus 10 are known as to their construction from the aforementioned document, they are not described herein in detail. The known membrane pillows 17, however are somewhat modified for use in the apparatus [illegible] A stabilizing element [illegible] is shown in Fig. [illegible] by dashed lines. The stabilizing element [illegible], which consists of plastic material, [illegible]

[illegible] spatial spacer elements supporting the membrane pillows [illegible].

The spacer elements 16 are annular in the embodiments of the apparatus 1 as shown in the figures. Preferably, they consist of an elastomer material such as rubber or of a corresponding suitable plastic material. The spacer element 16 includes an opening 161 [illegible] in size to the permeate discharge openings 174, 175 of the membrane pillow 17. For clarification, Fig. 6 is shown at an enlarged scale with respect to Fig. 5. The spacer element 16 provides a seal between two membrane pillows 17 as a result of the shape of the spacer element 16 itself or, additionally or alternatively, by a sealing element 163 shown in Fig. 6b by a dashed-dotted line representing for example an O-ring extending around the spacer element 16. The spacer element therefore forms a seal between two membrane pillows 17 between which it is engaged and determines also the distance between the two adjacent membrane pillows 17, which distance is established by its thickness. When the membrane pillows 17 are tightly stacked in a stack 18 with the spacer elements 16 disposed tightly between adjacent membrane pillows as shown in Fig. 2, no fluid 15 can escape to the permeate discharge openings 174, 175, because the spacer elements 16 form fluid seals if necessary in cooperation with sealing [illegible].

The permeate [illegible], [illegible] openings [illegible] 174, 175 of the membrane pillows 17, [illegible] permeate discharge [illegible]

leaves the membrane pillow 17 by way of the permeate discharge openings [illegible], is conducted away and flows through the permeate discharge openings [illegible] into the permeate discharge channels [illegible] of the shell elements [illegible].

The stack [illegible] described above is then set between two shell elements 19, [illegible] in a tight manner by fastening means which have been mentioned earlier. When the shell elements 19, 20 are joined it is made sure that the permeate separated by the permeate [illegible] pillows 17 leaves the permeate pillows through the permeate discharge openings of the membrane pillows 17 by way of the openings [illegible] of the spacer elements 16, the permeate discharge [illegible] of the drain [illegible] 164 and the permeate discharge openings 23, 24 of the shell elements 19, 20. The permeate is collected in the permeate discharge channels 22 of the shell elements 19, 20 and conducted from there to the permeate outlet 14 of the apparatus. All adjacent stack shells 27, 270 - in the example only two stack shells are shown - are removably interconnected by suitable connecting means incorporated into the stack shells 27, 270. These connecting means may be for example bayonet locks. Sealing elements arranged between the adjacent stack shells provide for a pressure tight fluid flow path with respect to the flow path of the permeate generated in the apparatus 10.

[illegible] and spacer [illegible] indicated in [illegible] by the diagonally crossed dash-dotted lines. The separating elements [illegible] by which the [illegible]

The membrane pillows 17 are arranged in each stack 15 in such a way that the fluid [illegible] flows around the membrane pillows in a meander-like pattern, see the flow pattern of two serially arranged stacks as shown in Fig. [illegible]. The membrane pillows 17 are [illegible] designed [illegible] that the two permeate discharge openings 174, 175 are arranged at different distances 179, 179' from the ends [illegible] of the membrane pillows 17. The larger distance 179' of the permeate opening 175 from one end of the membrane pillow as shown in Fig. [illegible] on the right ensures that the membrane pillow 17 abuts the separating element 31. The smaller distance [illegible] of the permeate discharge opening 174 from the other end of the membrane pillow 17, which is shown in Fig. 5 at the left provides for a space between the end 176 of the membrane pillow 17 and the separating element 31 thereby forming a fluid flow reversal path around the end 176 of the membrane pillow 17. With an alternate stacking of the membrane pillows 17 wherein each second membrane pillow 17 is turned by 180°, each second membrane pillow abuts with one end 177 the separating element 31. The same applies to the other end 176 where each first membrane pillow 17 engages the respective separating element 31 [illegible]. The fluid entering a stack 15 of membrane pillows 17 through the slot-like inlet 160 of the separating element 31 [illegible] is conducted by the [illegible] [illegible] separating element [illegible], which also forms the inlet [illegible] for the next downstream stack [illegible].

[illegible]

Then the plurality of stack shells 27 which are interconnected are inserted into an opening of the housing 11. It is made sure that the permeate discharge channels 22 of the stack shells 27 are joined in a pressure-tight manner and are continuous from the last stack shell 27 to a corresponding opening of the closure element 111 of the housing 11. Then the housing 11 is closed by the opposite closure element 110. The closure elements are locked in position by the locking rings 115 and 114 respectively, whereby it is made sure that any axial movement of the plurality of interconnected stack shells 27 in the housing 11 is prevented.

Subsequently, for the operation of the apparatus 10, the fluid 15 is introduced into the apparatus 10 by way of the inlet 12 and reaches the space 30 by way of the inlet 180 of the separating element 51 of the first stack 18. In the space 30, the fluid 15 flows around the membrane pillows 17 in a meander-like pattern to the outlet 181 of the first stack 18. The outlet 181 of the first stack 18 forms the inlet 180 of the separating element 51 of the second stack 8 so that the fluid 15 is conducted into the second stack 18. In the second stack, the fluid 15 again meanders past the plurality of membrane pillows 17. After passing through all the serially arranged stacks 18 the concentrated fluid 15, which is the retentate, leaves the [illegible] manner.

The permeate [illegible] membrane pillows 17 [illegible], by way of the [illegible] of the [illegible] openings 23, 24 [illegible] permeate discharge [illegible]